



DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT REPORT

ER 8-57

Project NS185-005 Subtask 4 Test 36

NORTHILL AIR LUNG FOURTH
FIELD TEST

C. J. Leyden

19 August 1956

Approved for public release; distribution unlimited.

PREPARED

SUBMITTED

APPROVED

C. J. LEYDEN
BM1 (DV), USN

W. F. SEARLE
LT, USN

M. des GRANGES
CDR, USN
Officer in Charge

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 19 AUG 1956		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE Navy Experimental Diving Unit Report ER 8-57: Northhill Air Lung Fourth Field Test				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) C.J. Leyden				5d. PROJECT NUMBER NS185-005	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Department of the Navy Navy Experimental Diving Unit Panama City, FL 32407				8. PERFORMING ORGANIZATION REPORT NUMBER ER 8-57	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT See report					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 21	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

ABSTRACT

This report covers the evaluation of the Northhill Air-Lung Regulator to determine the suitability of the apparatus for use in the Naval Service to depths of 200 feet at work rates equivalent to 0.85 knot swimming.

For the description of the demand regulator in detail, see Evaluation Report 3-57. The regulator was tested objectively by breathing machine runs and subjectively by depth swimming runs, with instrumentation for respiratory pressure, respiratory minute volume, and breathing rate. Subjective swimming pool tests covered in Evaluation Report 3-57 were not repeated here. Breathing machine runs are summarized as recording tape excerpts of peak respiratory pressure versus depth and cylinder pressure. The subjective depth swimming runs are summarized as graphs of peak respiratory pressure, respiratory minute volume, and respiratory rate against time, cylinder pressure, and depth.

The results are discussed constructively and lead to specific conclusions about the apparatus and its suitability for use in the Naval Service.

SUMMARY

PROBLEM

Is the Northhill Air-Lung Regulator suitable for use in the Naval Service to depths of 200 feet at work rates equivalent to 0.85 knot swimming?

FINDINGS

The general findings of Evaluation Report 3-57 remain unchanged except for satisfactory performance and suitability. The following specific findings apply to this evaluation.

- (1) The regulator is satisfactory for depths of 200 feet at work rates equivalent to 0.85 knot swimming.
- (2) The regulator meets NEDU Laboratory criteria of suitability for use in the Naval Service.

ADMINISTRATIVE INFORMATION

Ref: (a) BuShips - NEDU monthly conference, 4 May 1956
(b) Evaluation Report 3-57

Reference (a) established this project. Reference (b) is the first report for the project covering evaluation of the first, second and third field changes installed in Northill Air-Lung Regulator, serial 6-2427. As a result of the report, the regulator was not approved for use in the Naval Service.

The manufacturer requested permission to submit a modified regulator for evaluation. The Bureau of Ships granted permission.

On 23 July 1956, Mr. R. Bicknell delivered by hand Northill Air-Lung Regulator, serial 6-B154, embodying the fourth field change.

C. J. LEYDEN, BML(DV), USN, was designated project engineer. Work commenced 30 July 1956 and was completed 17 August 1956.

The following breakdown indicates the manpower expended for this project:

<u>DESCRIPTION</u>	<u>MANHOURS</u>
Preparations	10
Breathing machine tests	8
Depth swimming runs	36
Drafting	10
Reporting	<u>20</u>
TOTAL	84

This manuscript was submitted for review on 19 August 1956 and was accepted 27 August 1956.

This report is issued in the Evaluation Report series, distributed only by the Bureau of Ships. It is the second and final report for Project NS185-005, Subtask 4, Test 36.

CONTENTS

ABSTRACT	ii
SUMMARY	ii
ADMINISTRATIVE INFORMATION	iii
CONTENTS	iv

1. OBJECT
 - 1.1 Objective
 - 1.2 Scope
2. DESCRIPTION
 - 2.1 General
3. PROCEDURE
 - 3.1 Breathing machine tests
 - 3.2 Subjective depth swimming runs
 - 3.3 Depth run instrumentation
 - 3.4 Pool tests
4. RESULTS
 - 4.1 Breathing machine tests
 - 4.2 Subjective depth runs
5. DISCUSSION
 - 5.1 Breathing machine tests
 - 5.2 Subjective depth runs
6. CONCLUSIONS
 - 6.1 Characteristics
 - 6.2 Suitability
7. FIGURES
 - 7.1 Breathing machine runs
 - 7.2 Subjective depth swimming runs

1. OBJECT

1.1 Objective

1.1.1 The objective of this evaluation is to determine the suitability of the Northhill Air-Lung and its fourth field change for use in the Naval Service to depths of 200 feet at work rates equivalent to 0.85 knot swimming.

1.2 Scope

1.2.1 This report covers the limited evaluation procedure for Class I Open-Circuit Demand Diving Apparatus. This evaluation includes objective breathing machine tests to 132 feet and subjective depth swimming runs to 130, 150, and 220 feet at work rates equivalent to 0.85 and 1.31 knot swimming.

2. DESCRIPTION

2.1 General

2.1.1 The Northhill Air-Lung Regulator furnished for this evaluation was a modification of the regulator previously furnished and evaluated in Evaluation Report 3-57. Since the modification resulted in a different of spring tensions only, the description of the Northhill Air-Lung Regulator breathing tubes, and mouthpiece may be found in Evaluation Report 3-57 (Section 2).

3. PROCEDURE

3.1 Breathing machine tests

3.1.1 The descent and 132 foot runs were made as follows. The breathing machine was set at 20 breaths per minute and 2 liters per breath.

3.1.2 The 1 psi strain gage was rigged in the recompression chamber. The analyzer was calibrated and the attenuation was set to give one line of deflection for one centimeter of water pressure. On the recording tape the following was noted: "Northhill Air-Lung", date, calibration, attenuation, and the direction of deflection for inhalation and exhalation.

3.1.3 For these runs the Northhill Air-Lung Regulator was mounted on a two-cylinder Aqua-Lung manifold. The cylinders were charged to 1800 psi cool; the valves were opened and the apparatus was placed in the chamber. The air reserve device on the Northhill Regulator was cut into the system; the air reserve on the cylinders was cut out of the system.

3.1.4 A 3000 psi mechanical gage was rigged to the apparatus manifold. It was placed in the chamber port so as to be visible from the outside.

3.1.5 The mouthpiece connector was inserted into the mouthpiece and taped securely. The pressure tap on the mouthpiece was connected to the signal side of the 1 psi strain gage. The reference side of the strain gage was opened to the chamber and the chamber door was then closed.

3.1.6 The breathing machine was started and the breathing pressure recorder was turned on. The chamber was taken down to 132 feet at a rate of 20 feet per minute, marking every ten feet and each atmospheric increment on the recording tape. Each 100 psig decrement of falling cylinder pressure was also marked on the recording tape. Upon reaching 132 feet the breathing machine was stopped and the breathing pressure analyzer was checked for balance.

3.1.7 The breathing machine was restarted. The chamber was kept at 132 feet and the breathing machine was run until the inhalation pressure reached 40 centimeters of water pressure. At this point the run was terminated, the breathing pressure analyzer was checked for balance and calibration, and the chamber was then returned to the surface.

3.1.8 The cylinders were recharged to 1800 psi cool, the valves were opened, and the apparatus was replaced in the chamber. The air reserve device on the apparatus was cut out of the system and a second run was made following the same procedure.

3.1.9 The ascent and surface runs were made as follows. Steps 3.1.1 through 3.1.5 were repeated. The chamber was taken down to 132 feet. At 132 feet the breathing pressure analyzer was rebalanced and the breathing machine was turned on. At a rate of 20 feet per minute the chamber was returned to the surface, marking every ten feet and each atmospheric increment on the recording tape. Every 100 psig of falling cylinder pressure was also marked on the recording tape. Upon reaching the surface, the breathing machine was stopped and the breathing pressure analyzer was checked for balance.

3.1.10 The breathing machine was restarted. The chamber was kept at the surface and the breathing machine was run until the inhalation pressure reached 40 centimeters of water pressure. At this point, the run was terminated and the breathing pressure analyzer was checked for balance and calibration.

3.1.11 The cylinders were recharged to 1800 psi cool. The air reserve device on the regulator was cut out of the system and a second run was made following the same procedure.

3.1.12 The surface supplied run made in the Evaluation Report 3-57 was not duplicated for this evaluation.

3.2 Subjective depth swimming runs

3.2.1 For these runs the Northill Regulator was mounted on the two-cylinder Aqua-Lung, charged to 1800 psi cool. During the descent the apparatus was not used by the subject. Upon reaching the bottom the subject donned the apparatus, and assumed his position on the swimming trapeze. The remainder of the first five minutes was used to adjust the instruments. At 5 minutes the subject started to swim on the trapeze against the designated force for his particular run.

3.2.2 Due to a conflicting schedule, the depth swimming runs were made at varying depths. Two runs were made at 130 feet, two runs were made at 150 feet, and two runs were made at 220 feet. Four runs were made at the standard swim rate of 0.85 knots. Two runs were made at the spurt swim rate of 1.3 knots.

3.3 Depth run instrumentation

3.3.1 A 1 psi differential strain gage, with the signal side tapped into the mouthpiece tee, was used to measure breathing pressures. The reference side was connected to a bubbler terminating at the demand regulator, with the open end down. Bubbling was kept at a minimum. The analyzer was calibrated before the run, and calibration was rechecked after the run. The analyzer was balanced before the run, on starting the swim, and whenever the center appeared to be drifting. Breathing pressures were recorded from the start of the swim until the run was terminated.

3.3.2 A mechanical pressure gage was used for measuring cylinder pressure. Falling cylinder pressures were noted every 100 psig and marked on the recording tape.

3.3.3 On all subjective depth swimming runs, the exhaled gas was trapped and led through a gas meter for measurement. The exhaled volume was recorded automatically.

3.3.4 The following information was recorded at the beginning and end of each recording tape: subject, equipment, date, calibration, attenuation, and direction of deflection for inhalation.

3.4 Pool tests

3.4.1 Pool test results for the previous evaluation are recorded in the Evaluation Report 3-57. As no pertinent data would have been added, pool tests for the regulator with the fourth field change installed were not made.

4. RESULTS

4.1 Breathing machine tests

4.1.1 Figure T-1 is the recording tape of run 1 on the breathing machine.

4.1.2 Figure T-2 is the recording tape of run 2 on the breathing machine.

4.1.3 Figure T-3 is the recording tape of run 3 on the breathing machine.

4.1.4 Figure T-4 is the recording tape of run 4 on the breathing machine.

4.1.5 The recording tapes show inhalation pressure, exhalation pressure, and cylinder pressure against depth.

4.2 Subjective depth runs

4.2.1 Figures D-1 and D-2 are graphs of the two subjective depth runs made to a depth of 130 feet at the standard swim rate.

4.2.2 Figure D-3 is a graph of the subjective depth run to a depth of 150 feet at the standard swim rate.

4.2.3 Figure D-4 is a graph of the subjective depth run to a depth of 220 feet at the standard swim rate.

4.2.5 Figure D-6 is a graph of the subjective depth run to a depth of 220 feet at the spurt swim rate.

4.2.6 The graphs show inhalation pressure, exhalation pressure, respiratory minute volume, and respiratory rate against depth and time.

5. DISCUSSION

5.1 Breathing machine tests

5.1.1 Figures T-1, T-2, T-3, and T-4 indicate that the Northhill Air-Lung demand regulator embodying its fourth field change, satisfactorily meets the criteria for laboratory evaluation standards at the Navy Experimental Diving Unit. Inhalation and exhalation pressures did not exceed 10 cm of water at the surface or 20 cm of water at 132 feet with cylinder pressures of above 500 psi.

5.1.2 Comparison of Figures T-1, T-2, T-3, and T-4 indicates that the reserve device does not materially affect breathing pressures.

5.2 Subjective depth runs

5.2.1 Table 5-1 on the next page is a comparative summary of the important data appearing in Figures D-1 through D-6.

5.2.2 Runs 1 and 2 were made at 130 feet at the standard swim rate. Both runs remained within acceptable inhalation pressure limits. These results indicate that the Northhill Air-Lung Regulator is satisfactory for 0.85 knot swimming at 130 feet.

5.2.3 Run 3 was made at 150 feet at the standard swim rate. Inhalation pressures remained within acceptable limits. The results indicate that the Northhill Air-Lung Regulator is satisfactory for 0.85 knot swimming at 150 feet.

5.2.4 Run 4 was made at 150 feet at the spurt swim rate. Inhalation pressures remained within acceptable limits. The results indicate that the Northhill Air-Lung Regulator is satisfactory for 1.3 knot swimming at 150 feet.

5.2.5 Run 5 was made at 220 feet at the standard swim rate. A look at the graph of the run shows inhalation reaching 40 cm of water and exhalation 80 cm. There is reasonable doubt that these figures are incorrect due to a mechanical defect on the attenuation setting knob. If this is the case, the values of inhalation and exhalation pressures are in excess by approximately 2 1/2 times. A look at the record for run 6 which was a heavier swim rate would seem to bear out the belief that the values as presented for run 5 are in error. In view of these facts the Northhill Air-Lung Regulator is considered to be satisfactory for 0.85 knot swimming at 220 feet.

5.2.6 Run 6 was made at 220 feet at the spurt swim rate. Inhalation pressures remained within acceptable limits. The results indicate that the Northhill Air-Lung Regulator is satisfactory for 1.3 knot swimming at 220 feet.

5.2.7 A fluttering noise was encountered on run 1, on exhalation. A wheezing noise was encountered on runs 2, 5, and 6 on inhalation. No noise was encountered on runs 3 and 4. The same subject that made run 1 also made run 4. The same subject that made run 2 also made run 3.

5.2.8 The reason for the noises encountered was not determined. As it seems to be an engineering problem. The determination and elimination of the problem is left to the manufacturer.

6. CONCLUSIONS

6.1 Characteristics

6.1.1 The conclusions of Evaluation Report 3-57 concerning the Northhill Air-Lung demand regulator (6.1.1(1) through (4) 6.1.3) remain unchanged.

TABLE 5-1

COMPARATIVE SUMMARY OF INDIVIDUAL RESULTS

RUN NO.	TOTAL TIME OF RUN	CYLINDER PRESSURE		AVERAGE INHALA. PRESSURE IN cm PERIOD		MAXIMUM INHALATION PRESSURE	MAXIMUM EXHALATION PRESSURE	RESPIRATORY MINUTE VOL. IN LITERS*	RESPIRATORY RATE				
		Start psig	Stop psig	5-15 min.	20-30 min.	PEAK cm	TIME* min.	PEAK cm	TIME* min.	PEAK bpm	TIME min		
1	30	1600	350	8.5	14.0	30	26	20	28	**	8	12	
2	31***	1820	320	9.6	10.8	18	31	32	31	23	8	15	
3	36	1700	200	13.6	18.8	40**	36	34	19	20	12	8	11
4	15	1700	1000	16.3	****	18	12	30	11	24	11	9	11
5	18	1850	700	33.5*****		40	17	80	17	28	18	11	18
6	14	1640	180	19.6+	+	45++	14	50	14	**	23	12	

* First time only

** No record, machine failure

*** Cylinder pressure manually bled off for time periods 29 through 31 minutes

**** Valid only for period 5-15 minutes

***** Valid only for period 10-18 minutes

+ Valid only for period 5-14 minutes

++ Out of gas

6.2 Suitability

6.2.1 The Northhill Air-Lung Regulator is satisfactory for 0.85 knot and 1.3 knot swimming to depths of 220 feet. (5.2.2 through 5.2.6)

6.2.2 The Northhill Air-Lung Regulator meets NEDU Laboratory criteria of suitability for use in the Naval Service.

7. FIGURES

7.1 Breathing machine runs

7.1.1 Figure T-1 shows breathing pressures and cylinder pressure against depth to 132 feet. The reserve device was cut into the circuit.

7.1.2 Figure T-2 shows breathing pressures and cylinder pressure against depth to 132 feet. The reserve device was cut out of the circuit.

7.1.3 Figure T-3 shows breathing pressures and cylinder pressure against depth from 132 feet back to the surface. The reserve device was cut into the circuit.

7.1.4 Figure T-4 shows breathing pressures and cylinder pressure against depth from 132 feet back to the surface.

7.2 Subjective depth swimming runs

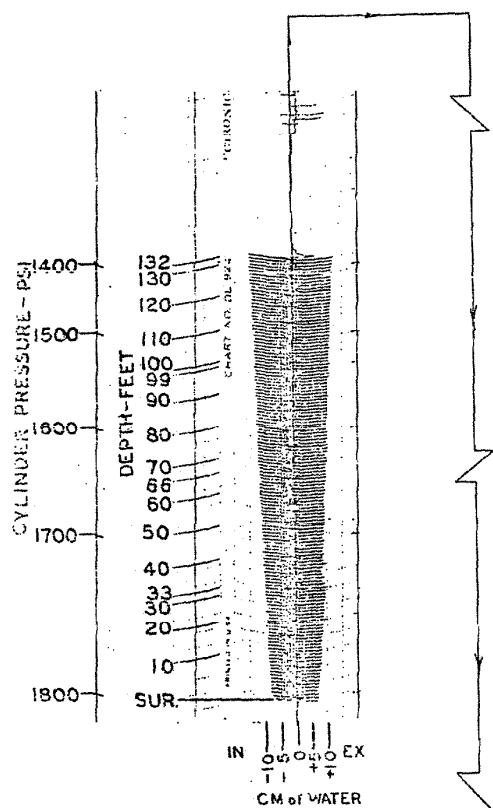
7.2.1 Figures D-1 and D-2 show the data for the standard (0.85 knot) swimming runs made at a depth of 130 feet.

7.2.2 Figure D-3 shows the data for the standard (0.85 knot) swimming run made at a depth of 150 feet.

7.2.3 Figure D-4 shows the data for the spurt (1.3 knot) swimming run made at a depth of 150 feet.

7.2.4 Figure D-5 shows the data for the standard (0.85 knot) swimming run made at a depth of 220 feet.

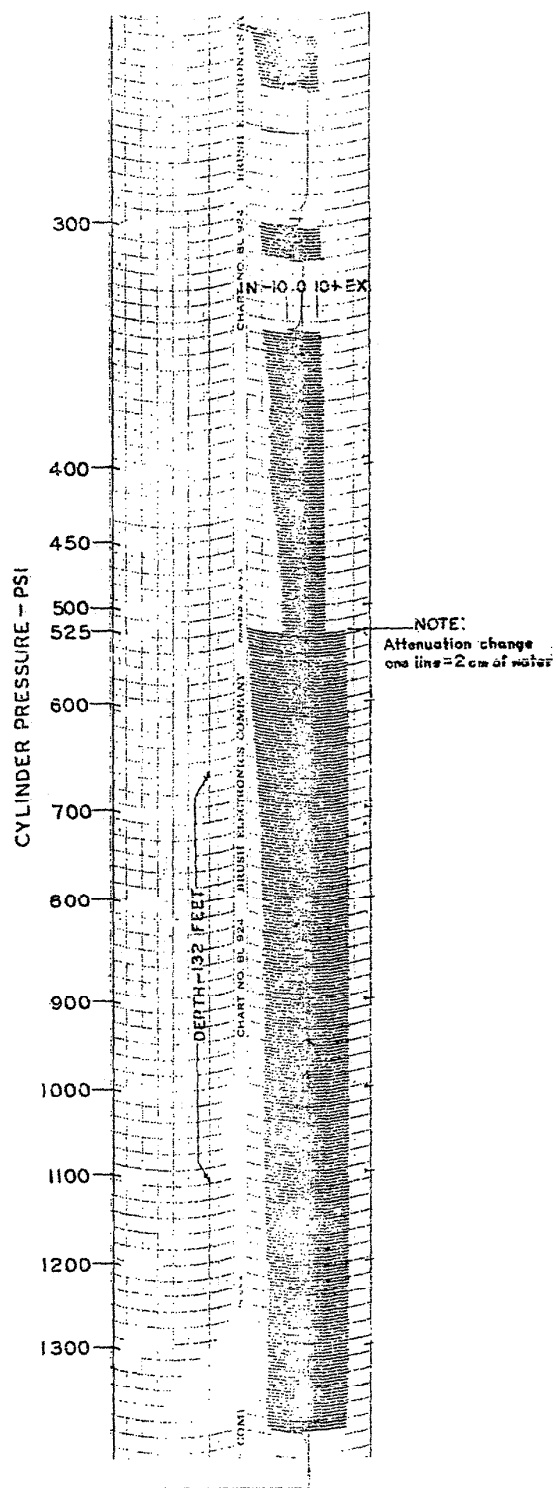
7.2.5 Figure D-6 shows the data for the spurt (1.3 knot) swimming run made at a depth of 220 feet.

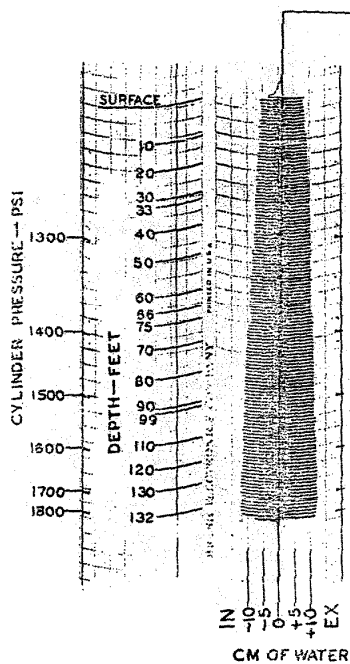


RUN No. 1
NORTHILL REGULATOR
Descent and 132 foot run with reserve
in system

Date: 30 July 1956

FIG. T-1



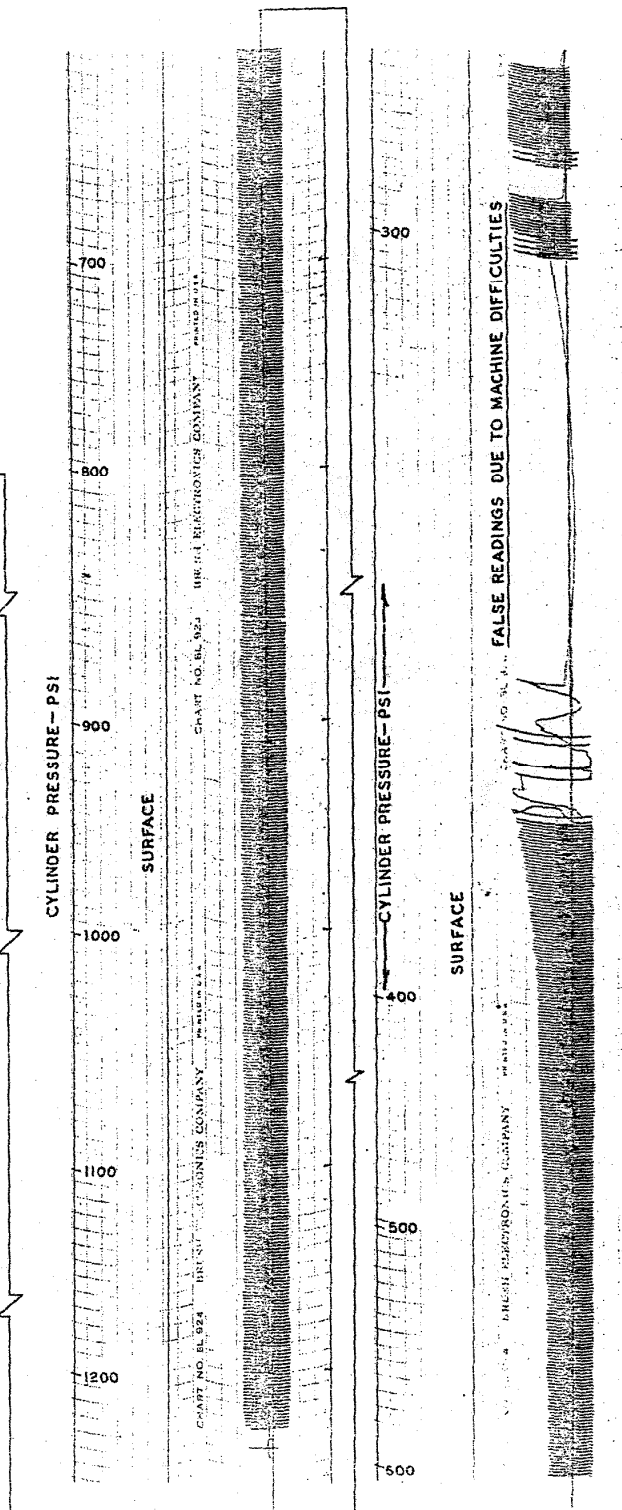


RUN No. 3 NORTHILL REGULATOR

Ascent and surface run with reserve
in system

Date: 30 July 1956

FIG. T-3



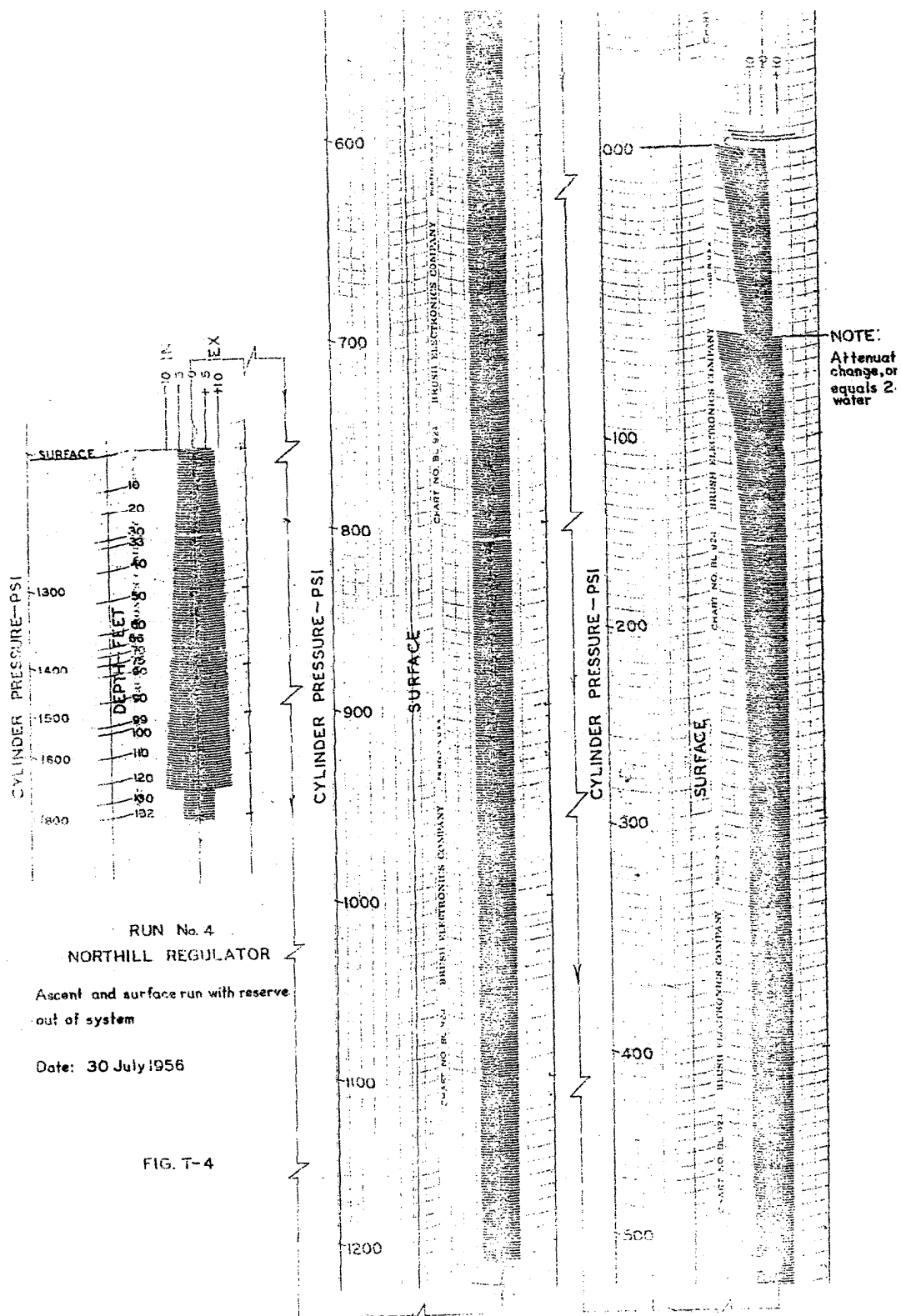


FIG. T-4

VENTILATION BREATHING PRESSURE AND CYLINDER PRESSURE

IN OPEN CIRCUIT SCUBA EVALUATION
AT 130 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN

PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUMES
VERSUS TIME

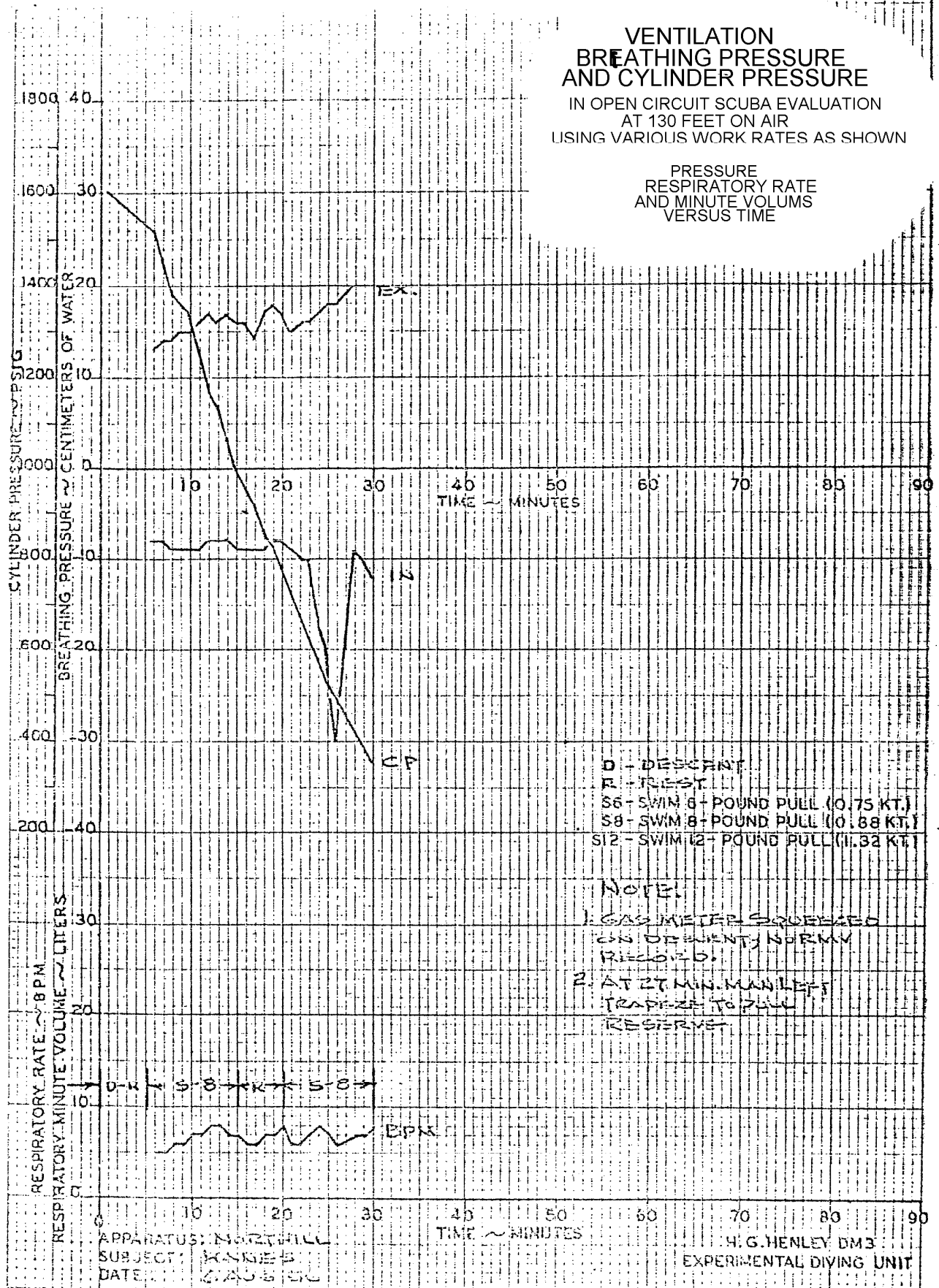


FIG. D-1

VENTILATION BREATHING PRESSURE AND CYLINDER PRESSURE

IN OPEN CIRCUIT SCUBA EVALUATION
AT 130 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN

PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUMES
VERSUS TIME

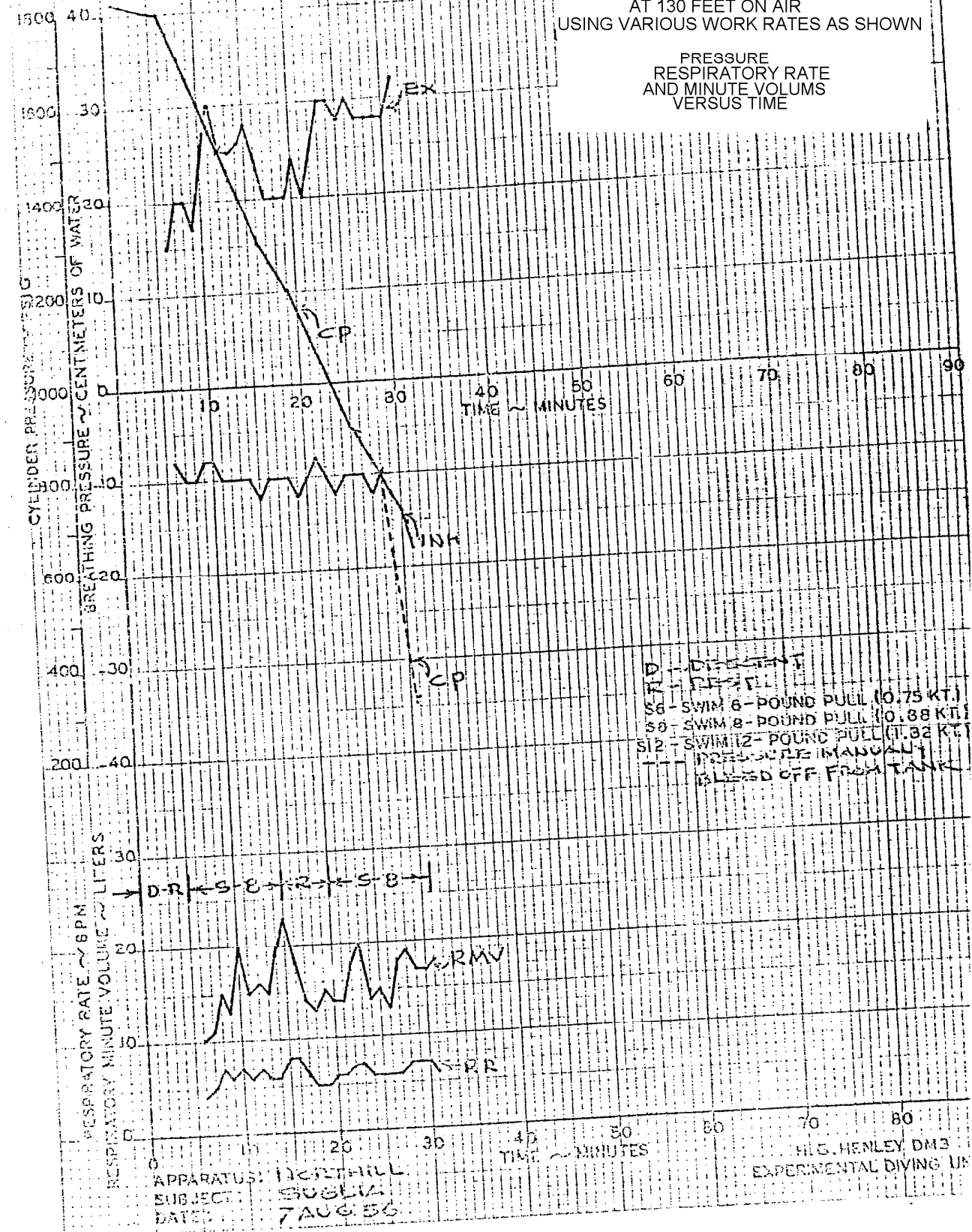
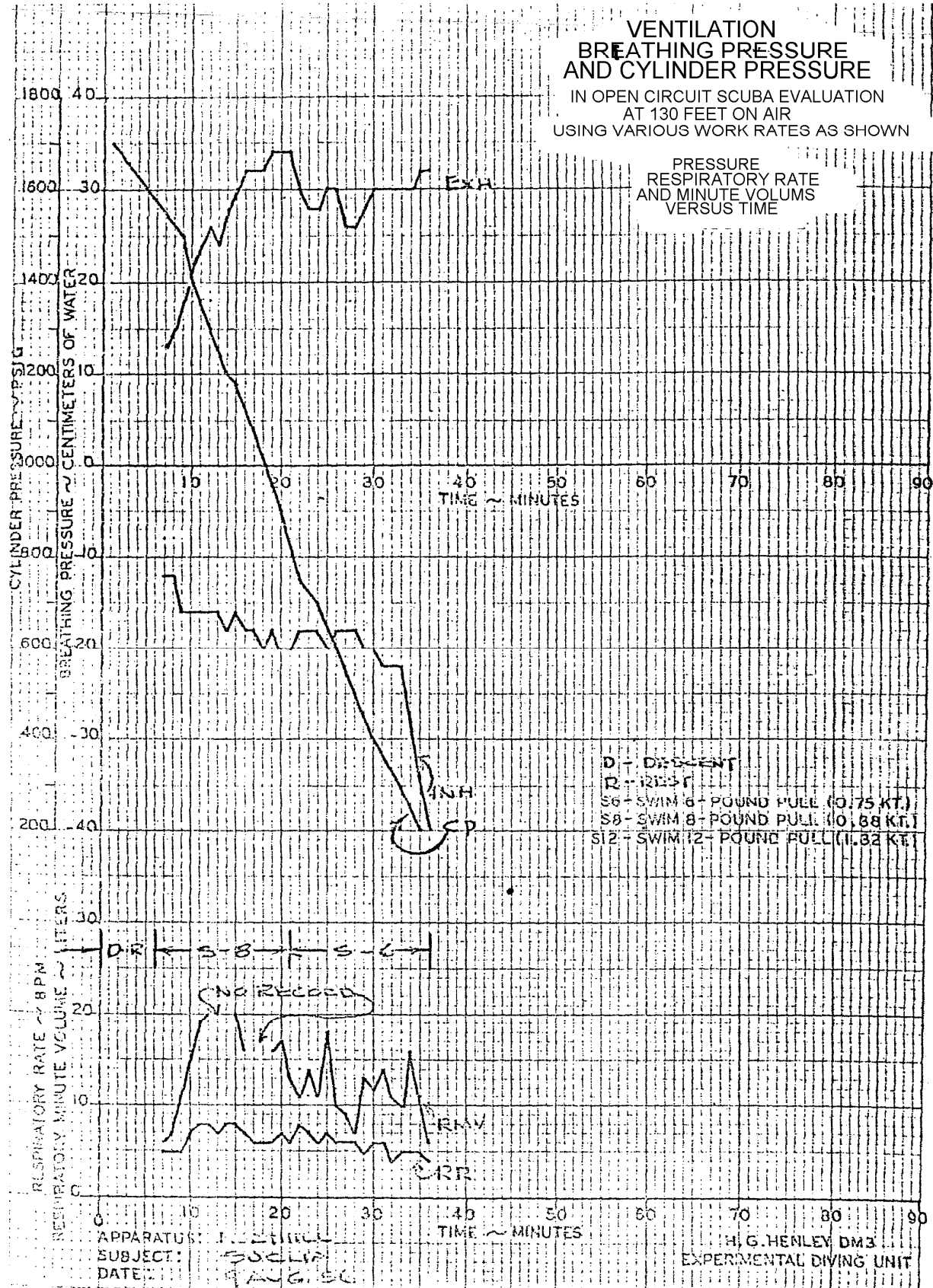


FIG-D-2

VENTILATION BREATHING PRESSURE AND CYLINDER PRESSURE

IN OPEN CIRCUIT SCUBA EVALUATION
AT 130 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN

PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUMES
VERSUS TIME



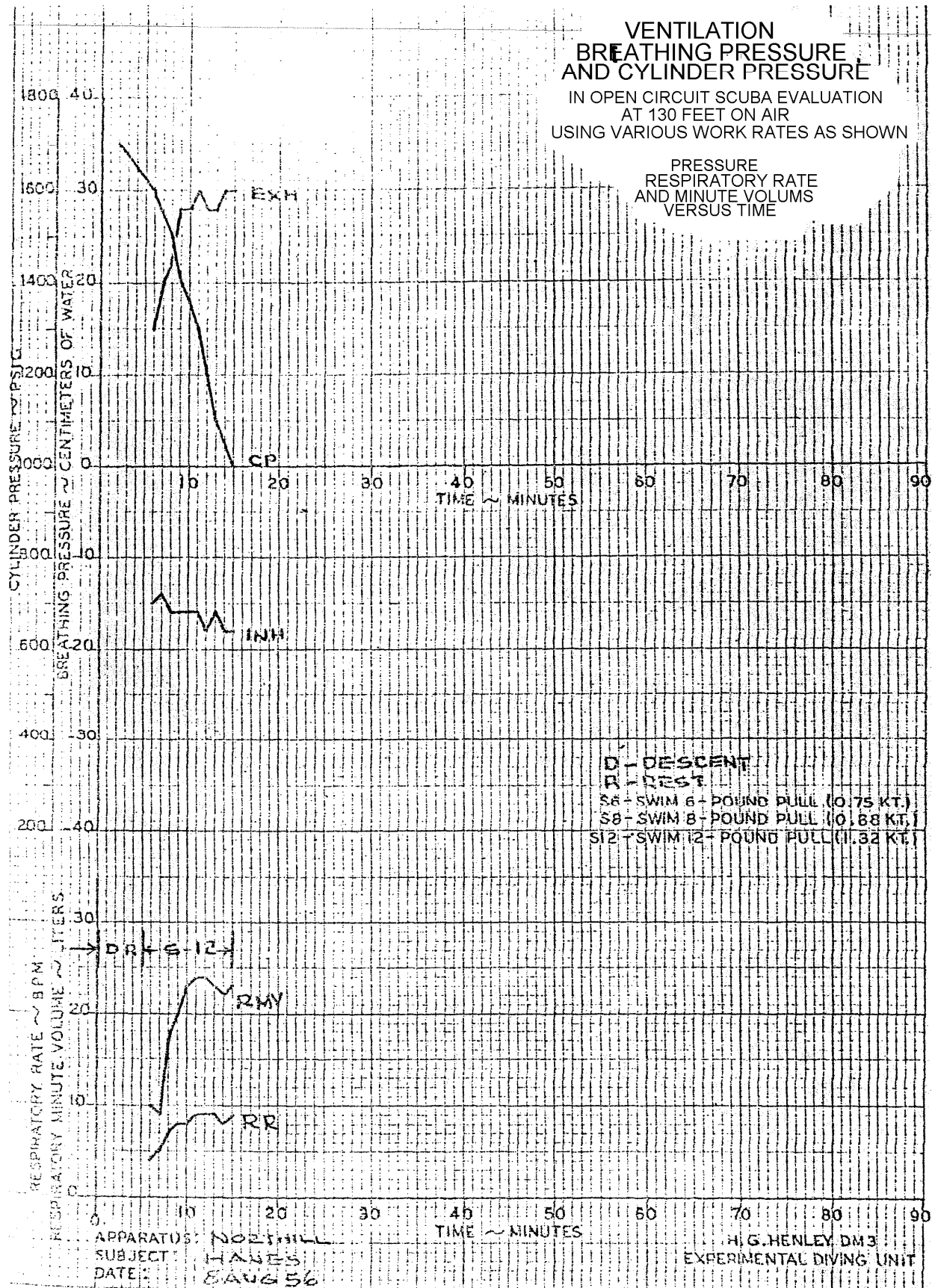
APPARATUS: J. STICK
SUBJECT: SUCLA
DATE: AUG 56

H. G. HENLEY DM3
EXPERIMENTAL DIVING UNIT

VENTILATION BREATHING PRESSURE AND CYLINDER PRESSURE

IN OPEN CIRCUIT SCUBA EVALUATION
AT 130 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN

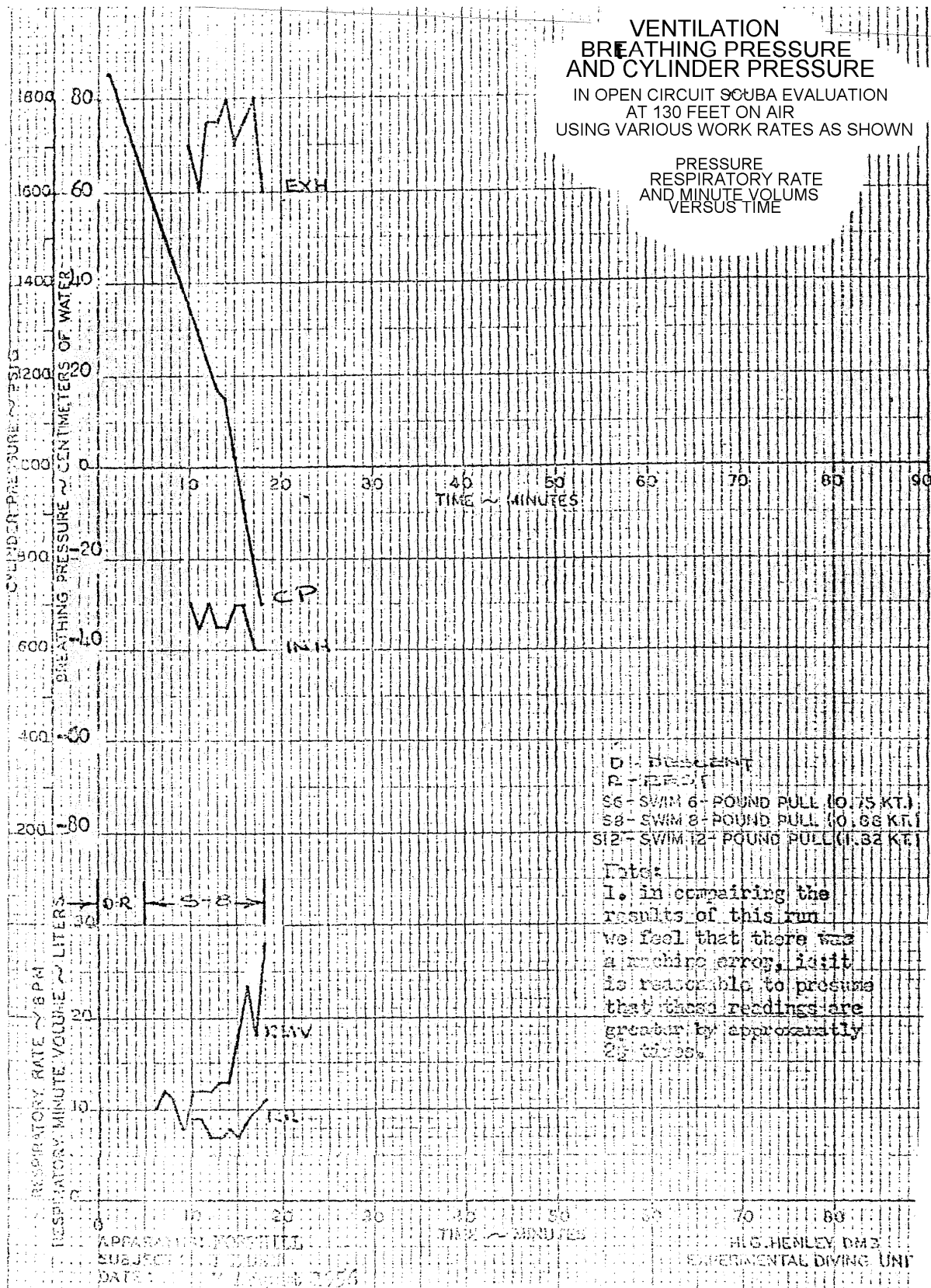
PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUMES
VERSUS TIME



VENTILATION BREATHING PRESSURE AND CYLINDER PRESSURE

IN OPEN CIRCUIT SCUBA EVALUATION
AT 130 FEET ON AIR
USING VARIOUS WORK RATES AS SHOWN

PRESSURE
RESPIRATORY RATE
AND MINUTE VOLUMES
VERSUS TIME



PRESSURE RESPIRATORY RATE AND MINUTE VOLUMS VERSUS TIME

